CLAIMS:

1. A micro pumping system for generating a liquid flow in at least one micro channel holding a liquid, the system comprising

- a substrate holding at least one micro channel with at least a first section having a first surface part and at least a second section having a second surface part,
- a light source adapted to emit a light beam, and
- moving means for inducing a relative movement between the light beam and the substrate,

the means for moving being adapted to move between at least a first position in which the light beam will irradiate the first surface part and a second position in which the light beam will irradiate the second surface part whereby at least one vapour bubble is formed acting on the liquid in the first and second section of the micro channel, respectively, in response to the irradiation of the respective surface parts of the micro channel.

2. A micro pumping system according to claim 1, wherein the light beam is continuously irradiating the micro channel when moving from the first position to the second position, creating at least one vapour bubble travelling from the first section to the second section.

3. A micro pumping system according to claim 1, wherein at least a first vapour bubble is formed in response to the light beam irradiating the first surface part and at least a second vapour bubble is formed in response to the light beam irradiating the second surface part.

4. A micro pumping system according to claim 3, wherein the at least second vapour bubble is formed before the at least first vapour bubble is collapsed.

5. A micro pumping system according to any of the preceding claims, wherein the micro channel has one or more regions, to be sequentially irradiated by the light beam, each region comprising a plurality of sections to be sequentially or continuously irradiated by the light beam.

6. A micro pumping system according to claim 5, wherein a region is irradiated by the light beam a number of times.

7. A micro pumping system according to claim 6, wherein the region is continuously or sequentially irradiated a number of times in either direction.

8. A micro pumping system according to claim 6, wherein the system is working bi-directionally.

9. A micro pumping system according to any of the preceding claims, wherein at least one surface part of the micro channel comprises a light absorbing material for absorption of optical energy.

10. A micro pumping system according to any of claims 1-9, wherein the optical energy is absorbed directly in the liquid in the irradiated section.

11. A micro pumping system according to any of the preceding claims, wherein the vapour bubble is formed in the liquid.

12. A micro pumping system according to claim 11, wherein the vapour bubble is formed by film boiling at least a part of the liquid in response to the light beam irradiation.

13. A micro pumping system according to any of claims 1-7, wherein the vapour bubble is formed in a buffer liquid.

14. A micro pumping system according to claim 13, wherein the vapour bubble is formed by film boiling of a part of the buffer liquid in response to the light irradiation.

15. A micro pumping system according to claim 13 or 14, wherein the vapour bubble is formed by nucleation in response to the light beam irradiation.

16. A micro pumping system according to any of claims 13-15, wherein the buffer liquid is held in a cavity associated with the micro channel, the surface part of the micro channel being a surface part of the cavity.

17. A micro pumping system according to claim 16, wherein the cavity has an opening towards the micro channel.

18. A micro pumping system according to claim 17, wherein the opening is smaller than cells to be transported by the liquid in the micro channel.

19. A micro pumping system according to any of claims 13-18, wherein the generated flow is laminar.

20. A micro pumping system according to claim 19, wherein the buffer liquid and the liquid are laminar flowing liquids in the micro channel.

21. A micro pumping system according to any of claims 13-20, wherein at least one section of the micro channel comprises the buffer liquid.

22. A micro pumping system according to claim 21, wherein an end section of the micro channel comprises the buffer liquid.

23. A micro pumping system according to any of the preceding claims, further comprising light beam control means for controlling parameters of the light beam.

24. A micro pumping system according to claim 23, wherein the light beam control means are adapted to control the parameters of the light beam to provide heating of a liquid in the micro channel.

25. A micro pumping system according to claim 24, wherein the light beam has an energy density adequate to heat at least a part of the liquid to a temperature below the boiling point of said liquid.

26. A micro pumping system according to any of the claims 24 or 25, wherein the energy density for heating a substantial amount of liquid is lower than the energy density for inducing bubble formation.

27. A micro pumping system according to any of the claims 24-26, further comprising a thermopile element for detection of liquid temperature.

28. A micro pumping system according to claim 27, wherein the thermopile element comprises an infrared detector.

29. A micro pumping system according to any of the preceding claims, further comprising control means for controlling the means for inducing the relative movement between the light beam and the substrate.

30. A micro pumping system according to claim 23 and 29, wherein the control means comprises the light beam control means.

31. A micro pumping system according to any of the preceding claims, wherein the means for moving the light beam in relation to the substrate comprises means for moving the substrate.

32. A micro pumping system according to any of claims 1-31, wherein the means for moving the light beam in relation to the substrate comprises means for moving the light source.

33. A micro pumping system according to any of claims 1-32, wherein the means for moving the light beam in relation to the substrate comprises means for moving the light beam.

34. A micro pumping system according to claims 33, wherein the means for moving the light beam comprises means for deflection or diffraction of the light beam.

35. A micro pumping system according to any of claims 31-33, wherein the means for moving comprises a motor

36. A micro pumping system according to any of claim 31-35, wherein the means for moving comprises piezoelectric elements.

37. A micro pumping system according to any of the preceding claims, further comprising a focusing means for focusing the light beam at a selected location.

38. A micro pumping system according to claim 37, wherein the selected location is a surface part of the micro channel.

39. A micro pumping system according to claim 37, wherein the selected location is a location in the micro channel.

40. A micro pumping system according to any of the claims 37-39, wherein the focusing means are controlled by focusing control means.

41. A micro pumping system according to claims 29 or 40, wherein the control means comprises the focusing control means.

42. A micro pumping system according to any of the preceding claims, wherein the velocity of the liquid is controlled by controlling the speed of the means for moving.

43. A micro pumping system according to any of the preceding claims, wherein the velocity of the liquid is controlled by controlling the energy density of the light source.

44. A micro pumping system according to any of the preceding claims, wherein dimensions of the vapour bubble are controlled by controlling an energy density of the light source and/or a period of irradiation of a selected section.

45. A micro pumping system according to claim 44, wherein the energy density and/or irradiation period of the light source is selected to form a vapour bubble having dimensions corresponding to micro channel dimensions.

46. A micro pumping system according to claim 45, wherein two fluctuating vapour bubbles are formed in two adjacent sections of the micro channel, the fluctuation being controlled so as to sustain at least one vapour bubble restriction in the channel.

47. A micro pumping system according to claim 45, wherein the vapour bubble is sustained by alternating heating a first and a second edge part of the vapour bubble by irradiating corresponding surface parts of the micro channel.

48. A micro pumping system according to any of the preceding claims, wherein at least one light source is controlled by the moving means to generate a flow in a number of micro channels.

49. A micro pumping system according to any of the preceding claims, wherein the moving means are controlled to irradiate a number of surface parts of a number of micro channels so as to generate a liquid flow in the number of micro channels.

50. A micro pumping system according to any of the preceding claims, wherein the light source is a laser

51. A micro pumping system according to any of the preceding claims, further comprising at least one reservoir for holding a marking liquid to be injected in the at least one micro channel, and a connecting bore linking the at least one reservoir at least one section of the at least one micro channel.

52. A micro pumping system according to any of the preceding claims, wherein the micro channel comprises at least a first liquid and a second liquid to be mixed, and wherein at least a first vapour bubble is formed in the at least first liquid in response to the irradiation of a first surface part of at least a first section, the vapour bubble being adapted to extend

into the second liquid, thereby increasing the boundary surface area between the first and the second liquid.

53. A micro pumping system according to claim 52, wherein at least a second bubble is formed in the at least second liquid in response to the irradiation of a second surface part of the at least second section, the vapour bubble being adapted to extend into the at least first liquid thereby increasing the boundary surface area between the first and the second liquid.

54. A micro pumping system according to any of the preceding claims, wherein the driving hydrostatic pressure is controlled by controlling the distance between the at least first and second sections of the micro channel.

55. A micro pumping system for pumping a liquid in a micro channel, the system comprising

- a substrate holding at least one micro channel with at least a first section having a first surface part and at least a second section having a second surface part,
- a light source adapted to emit a light beam, and
- means for moving the light beam in relation to the substrate,

the means for moving being adapted to move between at least a first position in which the light beam will irradiate the first surface part and a second position in which the light beam will irradiate the second surface part whereby at least a first vapour bubble is formed acting on the liquid in the first section and at least a second vapour bubble is formed acting on the liquid in the second section of the micro channel, respectively, in response to the irradiation of the respective surface parts of the micro channel, wherein the at least second vapour bubble is formed before the at least first vapour bubble is collapsed so as to provide a pumping action/so as to move liquid in the direction from the first to the second section.

56. A micro valve system comprising

- a substrate holding at least one micro channel with at least a first section having a first surface part and at least a second section having a second surface part,
- a light source adapted to emit a light beam, and
- means for moving the light beam in relation to the substrate,

the means for moving being adapted to move between at least a first position in which the light beam will irradiate the first surface part and a second position in which the light beam will irradiate the second surface part whereby at least a first vapour bubble is formed in liquid in the first section and at least a second vapour bubble is formed in liquid in the second section of the micro channel, in response to the irradiation of the respective surface

parts of the micro channel, wherein the first and second vapour bubbles are adapted to sustain a flow restriction in the channel by fluctuating the formation respectively the collapse of the at least two vapour bubbles.

57. A micro valve system according claim 56, wherein dimensions of the vapour bubbles are controlled by controlling an energy density of the light source and/or a period of irradiation of a selected section.

58. A micro valve system according to claim 57, wherein the energy density and/or irradiation period of the light source is selected to form at least one vapour bubble having dimensions corresponding to micro channel dimensions.

59. A micro valve system according to any of claims 56-58, wherein the first and second vapour bubble is the same vapour bubble sustained by alternating heating a first and a second edge part of the vapour bubble by irradiating corresponding surface parts of the micro channel.

60. A micro mixing system for mixing a plurality of liquids in a micro channel, the system comprising

- a substrate holding at least one micro channel with at least a first section having a first surface part and at least a second section having a second surface part,
- a light source adapted to emit a light beam, and
- means for moving the light beam in relation to the substrate,

the means for moving being adapted to move between at least a first position in which the light beam will irradiate the first surface part and a second position in which the light beam will irradiate the second surface part whereby at least a first vapour bubble is formed in a first liquid in the first section and at least a second vapour bubble is formed in a second liquid in the second section of the micro channel, in response to the irradiation of the respective surface parts of the micro channel, thereby increasing the boundary surface area between the first and the second liquid.

61. A thermal reactor system for heating a liquid in a micro channel, the system comprising

- a substrate holding at least one micro channel with at least a first section having a first surface part,
- a light source adapted to emit a light beam, and
- light beam control means for controlling parameters of the light beam,

wherein the light beam control means are adapted to control the parameters of the light beam to provide heating of a liquid in the micro channel.

62. A system according to claim 61, further comprising a thermopile element for detection of liquid temperature.

63. A system according to claim 62, wherein the thermopile element comprises an infrared detector.

64. A system according to any of the claims 61-63, wherein said liquid comprises a nucleic acid (NA) amplification mixture comprising a primer, a nucleic acid, a monophosphate nucleotide and an enzyme having a polymerase activity.

65. A micro system comprising one or more of the micro systems according to claims 1-64.

66. A method of generating a liquid flow in at least one micro channel, the method comprising

providing at least one substrate holding at least one micro channel,

emitting at least one light beam from at least one light source,

- inducing a relative movement between the at least one light beam and the at least one substrate so that the at least first light beam in a first position irradiates the first surface part and in a second position irradiates the second surface part,
- forming at least a first vapour bubble in the at least first section in response to the irradiation of the first surface part,
- forming at least a second vapour bubble in the at least second section in response to the irradiation of the second surface part,

the at least first and second vapour bubbles acting on the liquid in the first and second section of the micro channel, respectively, so as to generate a flow in the micro channel.

67. A method according to claim 66, comprising the step of continuously irradiating the micro channel when moving from the first position to the second position, creating at least one vapour bubble travelling from the first section to the second section.

68. A method according to claim 67, wherein at least a first vapour bubble is formed in response to the light beam irradiating the first surface part and at least a second vapour bubble is formed in response to the light beam irradiating the second surface part.

69. A method according to claim 68, wherein the at least second vapour bubble is formed before the at least first vapour bubble is collapsed.

70. A method according to any of claims 66-69, wherein the micro channel has one or more regions, to be sequentially irradiated by the light beam, each region comprising a plurality of sections to be sequentially or continuously irradiated by the light beam.

71. A method according to claim 70, wherein a region is irradiated by the light beam a number of times.

72. A method according to claim 71, wherein the region is continuously or sequentially irradiated a number of times in either direction.

73. A method according to claim 71, wherein the system is working bi-directionally.

74. A method according to any of claims 71-73, wherein at least one surface part of the micro channel comprises a light absorbing material for absorption of optical energy.

75. A method according to any of claims 71-74, wherein the optical energy is absorbed directly in the liquid in the irradiated section.

76. A method according to any of claims 71-75, wherein the vapour bubble is formed in the liquid.

77. A method according to claim 76, wherein the vapour bubble is formed by film boiling at least a part of the liquid in response to the light beam irradiation.

78. A method according to any of claims 71-77, wherein the vapour bubble is formed in a buffer liquid associated with the liquid in the micro channel.

79. A method according to claim 78, wherein the vapour bubble is formed by film boiling of a part of the buffer liquid in response to the light irradiation.

80. A method according to claim 72 or 78, wherein the vapour bubble is formed by nucleation in response to the light beam irradiation.

81. A method according to any of claims 78-80, wherein the buffer liquid is held in a cavity in associated with the micro channel, the surface part of the micro channel being a surface part of the cavity.

82. A method according to claim 81, wherein the cavity has an opening towards the micro channel.

83. A method according to claim 82, wherein the opening is smaller than cells to be transported by the liquid in the micro channel.

84. A method according to any of claims 71-83, wherein the generated flow is laminar.

85. A method according to claim 78-84, wherein the buffer liquid and the liquid are laminar flowing liquids in the micro channel.

86. A method according to any of claims 78-85, wherein at least one section of the micro channel comprises the buffer liquid.

87. A method according to claim 86, wherein an end section of the micro channel comprises the buffer liquid.

88. A method according to any of claims 66-87, further comprising controlling parameters of the light beam by light beam control means.

89. A method according to claim 88, wherein the light beam control means are adapted to control the parameters of the light beam to provide heating of a liquid in the micro channel.

90. A method according to claim 89, wherein the light beam has an energy density adequate to heat at least a part of the liquid to a temperature below the boiling point of said liquid.

91. A method according to claim 89, wherein the energy density for heating a substantial amount of liquid is lower than the energy density for inducing bubble formation.

92. A method according to claim 89 or 90, further comprising detection of liquid temperature by a thermopile element.

93. A method according to claim 92, wherein the thermopile element comprises an infrared detector.

94. A method of performing a nucleic acid (NA) amplification process comprising the steps of

a) providing a micro pumping system according to any of the claims 1-56,

b) providing an NA amplification mixture in a section of a micro channel, said NA amplification mixture comprising a primer, a nucleic acid, a monophosphate nucleotide and an enzyme having a polymerase activity.

c) heating the NA amplification mixture, using the light source, to achieve melting of double stranded DNA,

d) cooling the NA amplification mixture to achieve annealing of the primer to the nucleic acid,

e) allowing the enzyme having a polymerase activity to elongate the primer.

95. The method according to claim 94, further comprising repeating steps c) - e).

96. A method according to any of claims 66-93, further comprising controlling the means for moving the light beam in relation to the substrate by control means.

97. A method according to claims 66 or 96, wherein the control means comprises the light beam control means.

98. A method according to any of claims 66-97, wherein the means for moving the light beam in relation to the substrate comprises means for moving the substrate.

99. A method according to any of claims 66-93, wherein the means for moving the light beam in relation to the substrate comprises means for moving the light source.

100. A method according to any of claims 66-93, wherein the means for moving the light beam in relation to the substrate comprises means for moving the light beam.

101. A method according to claim 100, wherein the means for moving the light beam comprises means for deflecting or diffraction of the light beam.

102. A method according to any of claims 98-101, wherein the means for moving comprises a motor.

103. A method according to any of claims 98-102, wherein the means for moving comprises piezoelectric elements.

104. A method according to any of claims 66-103, further comprising focusing the light beam at a selected location by adjusting focusing means.

105. A method according to claim 104, wherein the selected location is a surface part of the micro channel.

106. A method according to claim 104, wherein the selected location is a location in the micro channel.

107. A method according to claims 104-106, further comprising controlling the focusing means by focusing control means.

108. A method according to claims 97 or 107, wherein the control means comprises the focusing control means.

109. A method according to any of claims 66-108, further comprising controlling the velocity of the liquid by controlling the speed of the means for moving.

110. A method according to any of claims 66-109, wherein the velocity of the liquid is controlled by controlling the energy density of the light source.

111. A method according to any of claims 66-110, further comprising controlling dimensions of the vapour bubble by controlling an energy density of the light source and/or a period of irradiation of a selected section.

112. A method according to claim 111, wherein the energy density and/or irradiation period of the light source is selected to form at least one vapour bubble having dimensions corresponding to micro channel dimensions.

113. A method according to claim 112, further comprising forming two fluctuating vapour bubbles in two adjacent sections of the micro channel, the fluctuation being controlled so as to sustain at least one vapour bubble restriction in the channel.

114. A method according to claim 113, wherein the vapour bubble is sustained by alternating heating a first and a second edge part of the vapour bubble by irradiating corresponding surface parts of the micro channel.

115. A method according to any of claims 66-114, wherein at least one light beam emitted from at least one light source is controlled by the moving means to generate a flow in a number of micro channels.

116. A method according to any any of claims 66-115, wherein the moving means are controlling the at least one light beam to irradiate a number of surface parts of a number of micro channels so as to generate a liquid flow in the number of micro channels.

117. A method according to any of claims 66-116, wherein the light source is a laser

118. A method according to any of any of claims 66-117, further comprising marking of at least one position in at least one micro channel by injecting a marking liquid from at least one reservoir for holding the marking liquid into the at least one micro channel via a connecting bore linking the at least one reservoir and the at least one position of the at least one micro channel.

119. A method according to any of claims 66-118, wherein the micro channel comprises at least a first liquid and a second liquid to be mixed, and wherein the first and second liquids are mixed by increasing the boundary surface area between the at least first and second liquids in that at least a first vapour bubble is formed in the at least first liquid in response to the irradiation of a first surface part of the at least a first section and at least a second vapour bubble is formed in the at least second liquid in response to the irradiation of a second surface part of the at least second section.

120. A method according to claim 119, wherein a plurality of vapour bubbles are formed sequentially in the first and second liquid, respectively, along a predetermined mixing length section of the micro channel.

121. A micro pumping system according to any of the preceding claims, further comprising controlling the driving hydrostatic pressure by controlling the distance between the at least first and second sections of the liquid channel.

122. A method of pumping a liquid in a micro channel, the method comprising the steps of

- providing a substrate holding at least one micro channel with at least a first section having a first surface part and at least a second section having a second surface part,
- emitting a light beam from a light source, and

- inducing a relative movement between the light beam and the substrate, so that the light beam in a first position irradiates the first surface part and in a second position irradiates the second surface part
- forming at least a first vapour bubble in the at least first section in response to the irradiation of the first surface part,
- forming at least a second vapour bubble in the at least second section in response to the irradiation of the second surface part,

wherein the at least second vapour bubble is formed before the at least first vapour bubble is collapsed so as to provide a pumping action.

123. A method according to claim 122, wherein the relative movement is obtained by moving the substrate, the light source, and/or the light beam.

124. A method of closing a micro valve in a micro system, the method comprising

- providing a substrate holding at least one micro channel with at least a first section having a first surface part and at least a second section having a second surface part,
- emitting a light beam from a light source, and
- inducing a relative movement between the light beam and the substrate, so that the light beam in a first position irradiates the first surface part and in a second position irradiates the second surface part,
- forming at least a first vapour bubble in the at least first section in response to the irradiation of the first surface part,
- forming at least a second vapour bubble in the at least second section in response to the irradiation of the second surface part,

wherein the at least first and second vapour bubbles are adapted to sustain a flow restriction in the channel by fluctuating the formation respectively the collapse of the vapour bubbles to close the valve.

125. A method according claim 124, wherein dimensions of the vapour bubbles are controlled by controlling an energy density of the light source and/or a period of irradiation of a selected section.

126. A method according to claim 125, wherein the energy density and/or irradiation period of the light source is selected to form at least one vapour bubble having dimensions corresponding to micro channel dimensions.

127. A method according to any of claims 123-126, wherein the first and second vapour bubble is the same vapour bubble sustained by alternating heating a first and a second

edge part of the vapour bubble by irradiating corresponding surface parts of the micro channel.

128. A method according to any of claims 123-127, further comprising the step of opening the valve by allowing the sustained vapour bubble to collapse.

129. A method of mixing at least a first and a second liquid in a micro channel, the method comprising

- providing a substrate holding at least one micro channel with at least a first section having a first surface part and at least a second section having a second surface part,
- emtting a light beam from a light source,
- inducing a relative movement between the light beam and the substrate, so that the light beam in a first position irradiates the first surface part and in a second position irradiates the second surface part
- forming at least a first vapour bubble in at least a first liquid in the first section in response to the irradiation of the first surface part,
- forming at least a second vapour bubble in at least a second liquid in the second section in response to the irradiation of the second surface part

thereby increasing the boundary surface area between the first and the second liquid so as to obtain a mixing of the at least first and second liquids.

130. A method of mixing according to claim 129, further comprising the step of repeating the steps of forming first and second vapour bubbles in a plurality of sections along the micro channel.

131. A method of heating a liquid in a micro channel, the method comprising

- providing a substrate holding at least one micro channel with at least a first section,
- emitting a light beam from a light source towards the at least first section, and
- controlling parameters of the light beam,

so that the liquid in the micro channel is heated.

132. A method according claim 131, further comprising the step of focusing the light beam at a selected location.

133. A method according to claim 132, wherein the selected location is a surface part of the micro channel.

134. A method according to claim 132, wherein the selected location is a location in the micro channel.

135. A method according to any of claims 131-134, further comprising focusing control means for controlling the focusing means.

136. A method according to any of claims 131-135, further comprising the step of detection of liquid temperature.

137. A method according to claim 136, where the liquid temperature is determined by a thermopile element associated with the micro channel.

138. A method according to claim 137, wherein the thermopile element comprises an infrared detector.

139. A method of handling liquid in a micro pumping system comprising one or more of the methods according to claims 66-138.